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ABSTRACT

A study was undertaken to delineate and assess the comprehension monitoring activities adults employed when following directions to assemble a model. The study also examined the effects of mode of presentation on such activities. Twenty-six college students were assigned to one of three groups and given a model to assemble. One group received directions consisting of illustrations without text, one group received directions consisting of text without illustrations, and one group received instructions composed of both text and illustrations. The subjects were also given a sheet depicting the various parts of the model and the names of the parts. Half of the students were asked to verbalize as they worked, while half were asked only to think about what they were doing. The results indicated differences in monitoring activities in the students, suggesting that the activities could be categorized in a taxonomy of metacognitive strategies. The relationship between those strategies and the effectiveness of performance, however, was not clear. Subjects in the text only and illustration only conditions used both a greater variety and a greater number of strategies than did those in the illustration and text condition but this did not seem to lead to the most efficient performance. (Copies of the instructions are appended.) (FL)

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Comprehending Procedural Instructions: The Influence
of Metacognitive Strategies

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There may be a variety of ways in which individuals seek to comprehend meaning from procedural instructions comprised of pictures and text. Differences may be due to a particular learner's skills (activities), knowledge, or aptitudes. This study was conducted to examine one of these sources of differences, the learner's skills, and the relationship of these skills to the mode of instructional presentation.

In order to comprehend procedural directions, a reader may employ various activities or procedures. These activities are needed to evaluate and regulate the learner's understanding of the material. If such skills are lacking, comprehension will be impaired and performance will suffer. Individuals, then must be able to recognize when they have failed to understand a direction and must also know what to do when such comprehension failures occur. The latter activities may involve such strategies as re-reading the material, looking ahead, or simply continuing in the hope that clarification will soon be provided.

The term metacognition has been used to refer to this knowledge one has of his or her own cognitions and the regulation of those cognitions (Flavell, 1979). Examples of the self-regulatory activities include checking the outcome of the results, planning the next move, monitoring effectiveness, and testing, revising, and evaluating one's strategies (Brown, 1978). Most of the research in this area has focused on the metacognitive strategies of children, but differences in such strategies have also been found with adults (Thorndyke and Stasz, 1980; Baker and Brown, in press).

Poor readers and novices are assumed to be deficient in these comprehension monitoring activities. For example, chess experts can assess their ability more accurately than novices (Chi, 1978) and expert X-ray technicians are able to scan X-ray patterns more thoroughly and focus on more informative areas than novices (Thomas, 1968).

Few investigations, however, have been conducted to categorize and assess the types of comprehension monitoring activities used by adults. One situation in which adults are likely to use such activities is when they are asked to follow procedural instructions. This study was undertaken, then, to delineate and assess the comprehension monitoring activities adults employ when using directions to assemble a model.

The effects of the mode of presentation on such activities was also examined. Since it has been found that certain kinds of information are presented more effectively in pictures or in text (Bieger, 1981), it was expected that comprehension monitoring activities would differ for the mode of instructional presentation.

Method

Subjects. Twenty-six Cornell undergraduate, ten male and sixteen female, participated in the study. All were volunteers from an introductory psychology course.

Materials. The materials included parts from the Fisher-Technik 100 model kit and written instructions on how to form a toy loading cart. The Fisher-Technik kit is composed of colorful, plastic pieces that slide or snap together. When assembled, the toy loading cart is approximately 6.5 in. (16.51 cm) tall, 2.5 in. (6.35 cm) wide, and 2.5 in. (6.35 cm) deep.

Three sets of 16 individually mounted directions were used. The first set consisted of text without illustrations, the second set contained illustrations without text, and the third set contained both text and illustrations. These instructions were designed by Stone (1977) so that the information in the text and illustrations would be comparable. The procedural text and illustrations are shown in Figures 1 and 2 respectively.

Procedure. Each student was randomly assigned to one of three groups. Those in group one (N=8) received directions consisting of illustrations without text; those in group two (N=9) received directions consisting of text without illustrations

and those in group three (N=9) were given instructions consisting of both text and illustrations.

The students were told that they were going to build a model and could use the directions in any way that they wished. They were also given a separate sheet depicting the various parts and the names of those parts. In addition to the actual assembly, half of the students were asked to verbalize, and half to think about what they were doing as they worked and why they were doing it. All were given a practice task to familiarize them with the notion of self-report. The students were then videotaped individually as they attempted to assemble the toy loading cart.

After the completion of the final assembly, each student was interviewed and thanked for participating. Some were also asked to watch themselves on tape and comment on their thoughts and actions as they performed the task.

Results

The data from the videotaped protocols, interviews, and prompted recalls were analyzed to determine the various kinds of comprehension monitoring activities that occurred. Four main categories and several subcategories of strategies were observed. These appear in Table 1.

Preliminary Findings. The taxonomy was used to code the students' videotaped performance of the assembly task. This was an exploratory phase of the study and will be used later when another sample of subjects is given the same and slightly different instructions. The following data is therefore meant to be used descriptively.

Correlations were made between each of the four categories of the taxonomy and two measures of successful performance: time to completion (speed) and the number of uncorrected errors left at the end of the assembly (accuracy). The preliminary analysis showed no significant correlations between the first category of the taxonomy, planfulness, and either measure of success. Significant correlations, however, were found for the second and third categories.

In the second category, ways of following the instructions, significant correlations were found between concern with detail and time ($r=.36$, $p<.03$) and between concern with detail and the number of errors made ($r=-.39$, $p<.02$). In addition, while not significant, the correlation between checking one's work and the number of errors made approached significance ($r=-.32$, $p<.059$).

In the third category, evaluation of errors, a significant correlation was found between evaluation and time and between evaluation and error. These correlations were $r=.46$ ($p<.009$) and $r=.532$ ($p<.003$) respectively.

For the fourth category, reactions to mistakes or problems (remedial strategies) correlations were made between the total number of different strategies used for the entire task and the two measures of success. While a significant correlation was found between the number of strategies and time ($r=.88$, $p<.0001$), no significant correlation was found between this variable and the number of errors made ($r=.14$, $p<.23$). This same pattern was observed for the relationship between the number of different kinds of remedial strategies used and the two measures of success. While kinds of strategies and time was significantly correlated ($r=.77$, $p<.001$), kinds of strategies and errors was not ($r=.22$, $p<.13$). A summary of these correlations is presented in Table 2.

Both the sex of the subject and verbalization were not found to be related to either the two measures of success or strategy use. Information about strategy use and condition, however, is shown in Table 3. While the differences between the mean times to completion of the three groups approached significance ($p<.056$), no differences were found for the number of errors left uncorrected.

Table 3 shows the number and percentage of people in each condition who used the various kinds of strategies. As evident from this table, those in the text only and illustration only conditions used a greater number of strategies and used these strategies more often than those in the text and illustration condition. While certain strategies such as strategy 4 (reexamine the same instruction) were used with great frequency in all three conditions, other strategies such as

strategy 11 (rebuild problem area) were used infrequently and only in one condition.

This same kind of result is seen when comparing the 5 best assemblers with the 5 worst. The 5 best were identified by locating those who had both the fastest times and fewest errors while the 5 worst were those who had the slowest times and greatest number of errors. As with the data describing strategy use in the various conditions, the best and the worst model makers differed with respect to the number and kinds of strategies used. These results are presented in Table 4.

Discussion

The preliminary results of this study indicate that differences in monitoring activities are observed as students attempt to comprehend procedural instructions. Further, these activities may be categorized in a taxonomy of metacognitive strategies. The relationship between these strategies and effectiveness of performance, however, is not as clear.

One kind of metacognitive activity that did not seem to influence performance was planfulness. Those who were more planful in their attempt to assemble the model were neither more efficient nor accurate than those who were less planful. One possible explanation for this seemingly incongruent finding is that, for this particular task, planfulness was not necessary. The task may have been easy enough to accomplish without doing any planning.

Other strategies, however, were found to be related to successful performance. One of these involved ways of following the instructions. That is, those who checked their work and showed a concern with detail made fewer uncorrected errors than those who did not check and were careless. One paid the price for being so concerned with detail, however, because those who were meticulous tended to take longer to finish the assembly than those who were unconcerned with such detail.

Being able to evaluate one's mistakes quickly was also related to success as measured by speed and accuracy of performance. When problems did arise,

students showed a variety of remedial strategies. In addition, the pattern of these strategies seemed to vary for the three types of instructional materials that were used.

Those in the illustration only and text only conditions used both a greater variety and a greater number of strategies than those in the illustration and text condition. This suggests that the information in the illustrations and text is not comparable as Stone (1977) indicated. If information is lacking, students will need to try many different strategies in order to clarify what it is that they are supposed to be doing. This, in effect, is what the analysis indicated. For example, the failure to understand an instruction often led those in the text only condition to give up using that instruction and, instead, hypothesize about how to perform that particular subassembly. This strategy was seen much less frequently in both of the other conditions. While certain remedial strategies were very common and occurred in all three kinds of conditions, other strategies were seen only when the pictures or the text were used alone. These latter strategies may represent last ditch attempts to comprehend the material.

In general, the results showed that the greater the number of remedial strategies that were used, the longer it took to complete the assembly. It seems clear, then, that an abundance of strategies does not always lead to the most efficient performance.

This is highlighted by the comparison between the five best and the five worst model builders. The best assemblers were those who used the fewest number and least variety of strategies. On the other hand, the worst were very likely to employ a large number and many different kinds of strategies. These poor assemblers needed such active attempts at monitoring to help them comprehend the instructions. It's unclear, however, whether such results are due to the inadequacies of the instructions or the knowledge or ability of the subjects. The pattern of strategy use in the three conditions suggests that, for this task,

the problem may lie in the instructions. Further work is being done to explore the effect of the content of the instructions on strategy use. Additional plans include using the taxonomy of comprehension monitoring strategies to assess performance on other tasks.

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Figure 1

TEXT INSTRUCTIONS

1. To form column one: Assemble three large blocks end to end. Attach a small block to the tab end of column one.
2. To form column two: Assemble three other large blocks end to end. Attach the other small block to the tab end of column two.
3. To form the back: Move the columns so that they are parallel with each other. They should be about the width of two blocks apart. (Be sure that the tabs at the end of each column point in the same direction.)
4. Connect the two columns by inserting four flat pieces between them. Slide each flat piece into place using the side grooves in the blocks. (All the flat pieces should have their smooth sides on the same side.) They must be flush with the ends of the columns without tabs.
5. To form the axle assembly: Attach one angle block to the end groove of column one and attach the other angle block to the end groove of column two. (Be sure that the tabs of the angle blocks face the same direction as the smooth sides of the back.)
6. Insert the long rod through the two angle blocks.
7. To form the base: Fasten two large blocks end to end to form a short column. Attach a third large block to a flat piece by inserting the flared edge of the flat piece into a side groove of the block. (Be sure that the ends of the flat piece are flush with the ends of the block.)
8. Attach another large block to the other flared edge of the flat piece in the same way. (Be sure that the tabs of the blocks point in the same direction.)
9. Insert these two tabs into a side groove of the short column so that the side of the short column covers the ends of both large blocks and the end of the flat piece.
10. To attach the base to the axle assembly: Notice that the base has a column of two large blocks. One side of this column has a flat piece attached to it. Attach the opposite side of this column to the exposed tabs of the axle assembly. Be sure that the flat piece in the base has its smooth side up.
11. To form the wheel assemblies: Place a washer over each end of a long rod so that they are flush with the angle block.
12. Place a screw hub over each end of the long rod so that their threads point away from the angle blocks.
13. Next place a tire over each end of the rod. Next place a nut hub over each end of the long rod with their wings away from the screw hub. Screw the nut hubs and screw hubs together with the tires between them. Finally, place a washer over each end of the long rod so that they are flush with the screw hubs.

14. To form handle one: Insert a short rod through a clip so that the clip is in the middle of the rod.
15. To form handle two: Insert another short rod through another clip so that the clip is in the middle of the rod.
16. Next, the handles should be inserted in the end of the back with exposed tabs. Each handle should be inserted in the grooves at the front of the back so that the clips are resting against the ends of the blocks. The openings on one side of each clip should fit over the tabs at the ends of the columns. This completes the assembly of the loading cart.

Figure 2
Plates of Illustrations
(not shown in accurate scale)



Plate #1

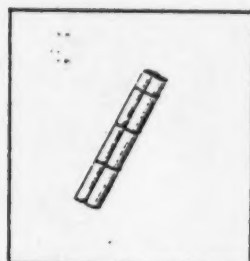


Plate #2

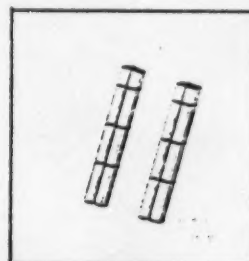


Plate #3

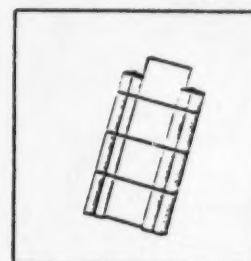


Plate #4

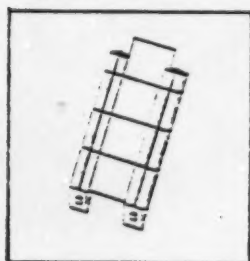


Plate #5

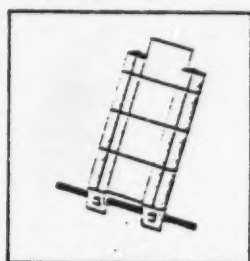


Plate #6

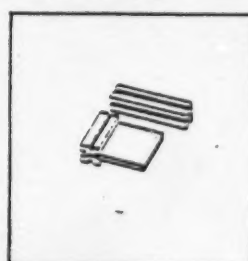


Plate #7

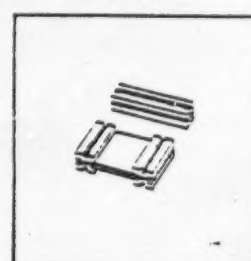


Plate #8

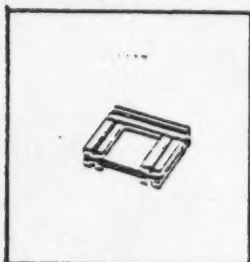


Plate #9

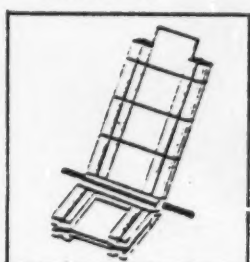


Plate #10

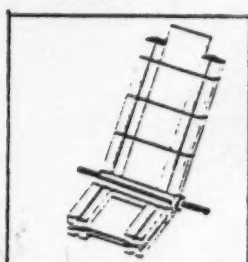


Plate #11

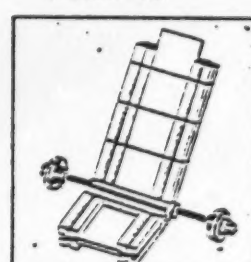


Plate #12

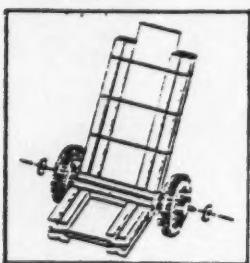


Plate #13



Plate #14

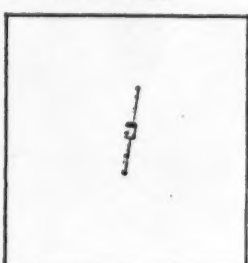


Plate #15

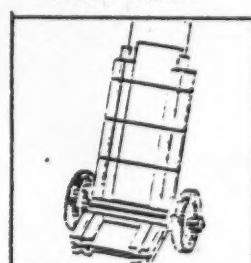


Plate #16

Table 1
A Taxonomy of Comprehension Monitoring Strategies

- A. Planfulness
 - 1. Initial approach to instructions (before assembly)
 - a. Look through instructions before starting task
 - b. Proceed step by step
 - c. Examine the display of parts before starting task
 - 2. During assembly
 - a. Look through several instructions before attempting a subassembly
 - b. Notice parts, instructions, etc., that may be needed at a later time
 - 3. Selection of parts
 - a. Select the parts needed for each subassembly
 - b. Dump all parts out on the work area
 - c. Select parts one at a time
- B. Ways of Following the Instructions
 - 1. Check each subassembly after completion
 - 2. Display concern for detail
- C. Evaluation of Errors
 - 1. Immediate evaluation
 - 2. Evaluation contingent upon a subsequent assembly
 - 3. Evaluation contingent upon parts remaining after assembly
 - 4. No evaluation made (error undetected)
- D. Reactions to Mistakes or Problems
 - 1. Examine the construction vs. take it apart immediately
 - 2. Examine instructions subsequent to the problem
 - 3. Examine instructions preceding the problem
 - 4. Reexamine the same instruction continuously
 - 5. Experiment with the parts
 - 6. Hypothesize; reason
 - 7. Build another part of the assembly
 - 8. Examine the sheet depicting the parts
 - 9. Compare two instructions
 - 10. Replace one part with the same part
 - 11. Rebuild the problem area in exactly the same way.

Table 2
Correlations Between Categories of the Taxonomy and Success

<u>Strategy</u>	<u>Time</u>	<u>Uncorrected Errors</u>
Planfulness	$r = -.11$	$r = -.04$
Ways of Following Instructions		
1. Concern with Detail	$r = .36$ ($p < .03$)	$r = -.39$ ($p < .02$)
2. Check Work	$r = .07$	$r = -.32$ ($P < .059$)
Evaluation of Error	$r = .46$ ($p < .009$)	$r = .53$ ($p < .003$)
Remedial Strategies		
1. # of different Strategies	$r = .88$ ($p < .0001$)	$r = .14$
2. # of different kinds of strategies	$r = .77$ ($p < .001$)	$r = .22$

Table 3
Remedial Strategy Use by Condition

Condition

Types of Remedial Strategies

	1	2	3	4	5	6	7	8	9	10	11
Illustration Only (N = 8) $\bar{X}$ time=916sec. $\bar{X}$ error = .75	* 13% ** .33	50% .88	50% .88	86% 1.8	50% 1	25% .25	25% .38	36% .50	13% .38	38% .63	0
Text Only (N = 9) $\bar{X}$ time=1266sec $\bar{X}$ error = .778	* 44% ** .56	44% .44	78% 1.4	100% 3.6	56% .78	56% 1.4	56% 1	89% 2.2	33% .33	0	33% .33
Illustration and Text $\bar{X}$ time=591sec $\bar{X}$ error = .448	* 0 **	0	0	100% 2.2	56% .56	11% .11	0	44% .44	0	0	0

* Percent of people in each condition who used strategy at least once

** Mean number of times strategy was used per person

Table 4
Remedial Strategies Used by Best and Worst Assemblers

Types of Assemblers	Types of Remedial Strategies										
	1.	2	3	4	5	6	7	8	9	10	11
Best (N = 5) $\bar{X}$ time = 680 sec $\bar{X}$ errors = 0	* 0 **	0	20% .2	80% 1.4	40% .4	0	0	40% .4	0	0	0
Worst (N = 5) $\bar{X}$ time = 2265 sec $\bar{X}$ error = 1.4	* 80% ** 1.4	100% 1.6	80% 2.4	100% 3.6	100% 2	80% 2.6	80% 1.8	80% 2.8	40% .4	20% .2	20% .4

* Percentage of people who used strategy at least once

** Mean number of times strategy used per person